# HYDROGEOLOGY AND GROUND WATER DEVELOPMENT PROSPECTS OF KANPUR METROPOLIS, UTTAR PRADESH



## INTRODUCTION

Kanpur Metropolis, the largest city of Uttar Pradesh and the eight largest city of India, is located on western bank of river Ganga. Kanpur city occupies a geographical area of about 278 sq. km. In the central part of U.P., lying between latitude 26°20' and 26°35' north and longitude 80°10' and 80°30' east (Survey of India Toposheet No. 63 B). The city has considerably grown up in recent times and developed in all field of activities.The city population which was about 2.10 million as per 1991 census, has become about 2.5 million by 1997.The Kanpur is famous for Leather and Textile industries.

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## PHYSIOGRAPHY

Kanpur metropolis forms a part of Ganga sub-basin in the Central Indo-Gangatic Plain. It exhibits more or less a flat topography with the master slope from north-west to south-east. The average elevation of land surface is 125 m.a.m.s.l. The area is drained by the river Gange and its tributary Pandu. The area of city has been geomorphologically divided into two units.

(i) Low lands or Younger Alluvial Plain &
(ii) Up lands or Older Alluvial Plain.

The Low land or Younger Alluvial Plain has been identified as flat to gently sloping and slightly undulating terrain of large areal extent, formed by river deposition, and is limited along river Ganga with the breadth not exceeding 5 km. The sediments comprise of Recent unconsolidated alluvial material of varying lithology. The fluvial land-forms such as palaeochannel, meander scar and oxbow lakes are common features.

Further west of Younger Alluvial Plain is the area of stable upland which has been produced by extensive deposition of older alluvium comprising of coarse to fine sand, silt and clay. The patches of salt encrustations have been reported in the area around Panki and Chakeri.

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## CLIMATE

The area experiences sub-tropical climate with average normal annual rainfall as 833.50 mm which is mostly received through the south-west monsoon. (Monsoon-771.0 mm and Non-monsoon-62.5 mm).

The mean maximum monthly temperature (41.7°C) has been recorded during May and minimum (22.8°C) in January, the average annual maximum and minimum being 32.1°C and 19.3°C, respectively. During peak summer the termperature sometimes shoots upto 46°C while in peak winter it becomes as low as 4°C.

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## WATER SUPPLY STATUS

With the rapid urbanization, industrial development and steep growth in population, the demand of water has increased manifold. At present drinking water demand of the city is 650 MLD which is partially met, only 350 MLD is being supplied by Kanpur Jalsansthan with break up of 200 MLD from surface water and 150 MLD from ground water sources. There are about 109 tubewells within 400 m depth by state agencies. These tubewells yield about 1500 to 3000 lpm.

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## HYDROGEOLOGY

Kanpur metropolis forms a part of Central Ganga Alluvial Plain, underlined by unconsolidated sediments of Quaternary age comprising silt, clay, sand of various grades, gravel and kankar in varying proportion. Fig.1 shows the hydrogeology of the city area.

The Central Ground Water Board (CGWB) has undertaken exploratory drilling of 7 wells upto a maximum depth of 500 m out of 7 wells, 6 wells have

been converted into production wells and handed over to state govt. for their utilization.

Study of the boreholes drilled by C.G.W.B. under its exploratory/deposit well programme and a subsequent perusal of sub-surface geological cross-sections (Fig.2 & 3, reveal the following scenario of sub-surface configuration.

1. The unconsolidated alluvial sediments deposited over the undulatory surface of the basement rock, (encountered in borehole at Panki at the depth of 505 mbgl) show alternative clay and granular beds. The sandy horizons at different depths form the main repository of ground water.

2. The thick pile of sediments down to bed rock broadly, consist of 3 tier aquifer system as below:-

**1st Group of Shallow Aquifers (upto 150 m) depth bgl):**

Ground Water occurs under unconfined to semi confined conditions. The aquifers of this group do not appear to hold good promise for ground water development due to their lensoidal nature.Shallow tubewells ranging upto 100m depth tapping 7 to 20 metres of saturated granular zones, yield 7 to 20 lps at drawdown ranging between 4 to 7 metres. The tubewells, 101 to 175 meter deep and tapping 10.5 to 49.0 m of saturated granular zones,yield 12 to 27 lps at drawdown ranging between 5.85 and 10.45 m. Static water level in these wells varies from 6 to 14 meters. Generally, the tubewells tapping the 1st Group of aquifers are moderately yielding but do not give sustained water supply during the peak summer period.

**2nd Group of Moderately Deep Aqufiers (Existing between 150-250m depth):**

Ground water occurs under confined conditions. This particular aquifer group has not been exclusively tapped in any tubewell due to its poor quality of formation water. However, it has been observed that whenever even partly this aquifer group has been tapped in any tubewell along with overlying aquifer group, the yield of the well has remarkably increase, which confirms its potentialities. It appears that the confineness of this aquifer group due to overlying and underlying clay beds has restricted its flushing, resulting in the occurrence of poor quality of water in the aquifer.

**3rd Group of Deep Aquifers (below 250 m depth):**

Ground water occurs under confined conditions. The piezometric level of the deep aquifers ranges between 12.00 an 19.00 mbgl. The aquifers of this group are holding good promise for ground water development. Deep tubewells, 338 to 400m deep, tapping 34 to 89m of saturated granular zones,

yield 31 to 60 lps at drawdown ranging between 4 and 17m. Ranges of different parameters of these aquifers are given below.

| | |
|---|---|
| Specific Capacity | 2 – 11 lps/m |
| Transmissivity (T) | 1338 – 3916 $m^2$/day |
| Hydraulic Conductivity (K) | 33.70 – 75.00 m/day |
| Storativity (S) | $4.54 \times 10^{-5}$ – $8.6 \times 10^{-4}$ |

## Depth to Water Level

Depth water level in Kanpur metropolils generally varies from 6 to 16 mbgl during pre-monsoon period Fig.4 depicts that all along in the vicinity of river Ganga the water level rest at maximum depth ranging between 12 and 16 mbgl. The depth gradually reduces towards western direction. During Post-monsoon period water level shows a minor rise due to replenishment of aquifer by monsoon precipitation.

## Ground Water Flow

The pre-monsoon water table elevation contours map (fig.5) shows the highest water level elevation of 122 m in the western parts of Metropolis and lowest i.e. less then 107 m along river Ganga. The gradient of ground water table is steeper along the Ganga. The pattern of contours indicates that the ground water flow is, generally in eastern direction confirming the effluent nature of river Ganga.

## Long Terms Water Level Trend

The plot of long term water level data of hydrograph station located at Kanpur Kachehri Fig. 66 and also analysis of water levels of other hydrograph stations of metropolis show a general declining trend as given below.

## Water Level Trend Analysis

| Well No. | Location | Period of record | Mean depth to water level (mbgl) | Trend (m) |
|---|---|---|---|---|
| KNP-02 | Kanpur Kachehri | 1974-98 | 9.66 | - 7.22 |
| KNP-12 | Maharajpur | 1979-98 | 8.66 | - 9.66 |
| KNP-30 | Narmau (New) | 1988-98 | 1.78 | -0.22 |
| KNP-37 | Bithoors | 1989-93 | 11.96 | - 4.81 |
| KNP-40 | Samadhi Naubasta | 1992-98 | 4.95 | + 1.25 |
| KNP-41 | Ramadevi Ring Rd. | 1992-98 | 12.07 | - 1.20 |
| KNP-42 | Motipura | 1992-98 | 1.65 | - 0.92 |
| | | | Average = | - 3.25 |

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## HYDROCHEMISTRY & POLLUTION OF GROUND WATER

### a) Chemical Quality

The study of chemical analysis of ground water reveals ground water quality in Kanpur City as below:

1. By & large, the formation water is alkaline in reaction, bicarbonate type and moderately mineralized. The concentration of all the chemical constituents, except fluoride (F) at few locations, are well within the highest desireable or maximum permissible limits as laid down for drinking purpose by BIS-1991. The concentration of fluoride (F) at Phoolbagh, Bazza Purwa, Panki, Sachendi and Chakrapur localities have been found more than maximum permissible limit (1.5 mg/l) ranging between 1.6 and 2.2 mg/l.

2. The formation water of 2nd group of aquifer by and large, is brackish, alkaline, bicarbonate type and hard. The chloride contents range between 213 and 805 mg/1.

3. The ground water of the deep confined aquifer (3rd Aquifers Group, occurring within 250-450 mbgl depth) is quite fresh, soft to slightly hard and very much suitable for all the purposes.

## b) Ground Water Pollution

Kanpur, being an industrial metropolis, has a large number of industries of which leather, textile, jute and chemical industries are dominant. The unplanned disposal of domestic waste and discharge of untreated or partially treated effluents by the industries directly on land or in Ganga river are resulting into pollution of surface and sub-surface water.

During the recent studies by CGWB the contamination of ground water of toxic constituent like hexavalent chromium ($Cr^{+6}$) has been detected in the industrial pockets located at Nauriya Khera (Panki Thermal), Baburia, Rakhi mandi, Fazalganj and Jajmau areas. The ranges of chromium concentration in water of phreatic aquifers in these localities are as below.

| | | |
|---|---|---|
| Baburia | : | 0.510-7.223 mg/l |
| Rakhi Mandi | : | 0.007-10.00 mg/l |
| Fazalganj | : | 0.005-6.35 mg/l |
| Jajmau | : | 0.003-0.132 mg/l |
| Nauriya Khera (Panki Thermal) | : | 0.008-8.00 mg/l |

The main source of chromium concentration in ground water being the industrial effluents from Leather, Textile etc.

### Health Hazards due to Chromium

Chromium is the most toxic water pollutant. The concentration above 0.05 mg/l in drinking water may prove detrimental to human health. The higher concentration of chromium may cause cancer of lungs, nasal cavity and paranasal sinus, stomach and larynx. Skin decolourization and peptic ulcer are common disease in the inhabitants of this area.

### Remedial Measures

In order to combat with the chromium pollution in ground water, the following measures are suggested.

1. The deep tubewells tapping granular zones below 250 mbgl depth contain chromium free water, thus advice to promote the use of water from deeper aquifer instead of water from shallow zone in the chromium effected area.
2. The factories effluents should be well treated before disposal.
3. Proper surface drainage and sewerage system should be developed to prevent leaching of pollutants.

4. The public awareness should be generated in the chromium affected areas on the harmful effects of high chromium concentrations. Top

## STRATEGY FOR GROUND WATER AUGMENTATION

Not-withstanding the over-development of phreatic aquifer, Kanpur city still offers a good scope for creating the additional water resources. Because there is a substantial monsoon runoff going unutilized, that otherwise can be conserved as a sub-surface storage on account of the available column and permeable material. Basically there are two techniques feasible in densely populated area, namely, roof top rainwater harvesting and runoff water conservation.

### Roof Top Rain Water Harvesting

The roof top water from the dwelling units and buildings may be diverted to a community well to allow the rain water infiltrate down and recharge the ground water. The technique of storage is quite simple and inexpensive since the roof top water can be pooled in a pit filed in the annular space with permeable gravel and sand. As a small beginning, every house should have a small pit and the water from the rooftop may be diverted through pipeline into the pit.

### Runoff Rain Water Harvesting

The surface runoff on the roads and open grounds is substantial especially during the monsoon period. Since the infiltration is negligible, the runoff flows out of the city unutilized. This creates problems of stagnation locally and obstructs drainage system. The surplus water may be diverted to pits (recharge shafts) judiciously constructed in the colony parks or playgrounds. Top

## CONCLUSION AND RECOMMENDATIONS

About 75% of the total water requirements of Kanpur Metropolis are met from surface water resources of river Ganga and Lower Ganga Canal while the balance is received from ground water. With the rapid urbanization and

growth of industries the extent of pollution of surface water resources has increased remarkably and in future these limited resources will not be able to meet out the water demand in the same ratio as today. Therefore it is imperative to make the fruitful long term planning to conserve these resources and utilize it in systematic way for the maximum benefit of society.

For the better utilization of ground water resources in Kanpur Metropolis the following suggestions are made.

1. Since the water levels are showing a continuous declining trend due to over development of 1st Aquifer Group, the further development of this group should immediately be minimized for some time and proper schemes should be taken up to artificially recharge it through roof top rainwater harvesting.

2. At places, the phreatic aquifer is getting polluted due to discharges of untreated or poorly treated industrial effluents on the low land area or directly in river Ganga. It should be checked.

3. It is imperative to explore the scope for utilizing the poor quality formation water of 2nd Aquifer Group (depth range : 150-250 mbgl) after proper blending with fresh water for domestic, industrial and gardening uses. It may be helpful in flushing of aquifers of this particular group and ultimately improving its quality in due course.

4. The main potential aquifers, i.e. 3rd Group of deep aquifers, exist in the depth range of 250 and 450 mbgl. The tubewells tapping these aquifers are capable of yielding 2000 to 3500 lpm. It is suggested that in future the domestic as well as industrial water supply in Kanpur metropolis and its environs should only be planned by expbiting this particular aquifer group, it will also reduce the over stress on shallow aquifers group. The distance between the two deep tubewells should not be less than 500 metres.

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